

What is claimed is:

1. An electrically conductive whip-like contact structure comprising:  
a flexible rod; and  
5 a conductive path along an exterior surface of the rod, the conductive path including one or more conductors having one or more metal strands bonded to the rod exterior surface by an adhesive.
2. The structure of claim 1 where:  
the adhesive includes a resinous material containing metallic particles.
- 10 3. The structure of claim 1 where:  
the one or more metal conductors include at least one conductor selected from the group consisting of a metal braid and a metal wire.
4. The structure of claim 3 where:  
the adhesive bonds the metal strands to the rod surface at interstitial  
15 locations between the metal strands.
5. The structure of claim 4 where:  
the adhesive includes a resinous material including at least one selected from the group consisting of epoxy resin, urethane resin, and silicone resin and contains metal particles.
- 20 6. The structure of claim 5 where:  
the rod is tapered and principally comprises fiber-reinforced plastic material.
7. The structure of claim 6 where:  
the one or more conductors have greater conductivity than the adhesive;  
25 and  
the outermost, exposed, surface of the metal strands is substantially free of the adhesive.
8. The structure of claim 7 where:  
the conductive path is formed principally of a tubular metal braid directly  
30 on the exterior rod surface with the adhesive on the exterior rod surface at at least some of the interstitial locations between the strands.

9. The structure of claim 6 where:

the flexible member includes at least a second tapered rod located within a part of the first mentioned tapered rod in a rod assembly and the rods have blunt ends at a common axial position with physical contact between adjacent rods.

5 10. The structure of claim 9 where:

the flexible member further includes a substantially all-metal rod portion having an end joined with the blunt ends of the rods in the rod assembly with the conductive path on the first mentioned rod conductively connected with the all-metal rod.

11. An electrically conductive whip-like contact structure comprising:

10 a tapered, elongated, and flexible member including first and second parts with an end of the first joined with an end of the second;

the first part being of substantially all-metal material;

the second part having a different composition than the first part with a density less than that of the first part; and

15 the first and second parts each having an electrically conductive surface forming a continuous conductive path along the outside of the joined parts.

12. The structure of claim 11 where:

the second part includes a tapered rod of nonmetallic material having one or more metal conductors thereon making up its electrically conductive path along the  
20 outside thereof.

13. The structure of claim 11 where:

the second part is joined with the first part at a joint including a metal spine located within the interior of the second part.

14. The structure of claim 12 where:

25 a metal spine extends within a tapered hollow of the second part from a first axial point near the first part to a second axial point outside of the joint between the first and second parts.

15. The structure of claim 14 where:

the metal spine is tapered in the same direction as the second part.

30 16. The structure of claim 14 where:

the metal spine is a member of a spring steel.

17. The structure of claim 14 where:

the rod of nonmetallic material of the second part principally comprises fiber-reinforced plastic material that has within the central tubular hollow thereof a second tapered, tubular rod that also principally comprises fiber-reinforced plastic material and that over a part of its length fits tightly together with the outer, first mentioned, rod and with the metal spine located within it.

18. The structure of claim 17 where:

the one or more metal conductors on the second part include at least one conductor selected from the group consisting of a metal braid and a metal wire adhesively bonded to the surface of the first mentioned rod of nonmetallic material.

19. The structure of claim 11 where:

the composition of the second part also has a greater specific strength than the all-metal material of the first part.

20. The structure of claim 19 where:

the composition of the second part comprises a member selected from the group consisting of fiber reinforced plastics and metal matrix composites.

21. The structure of claim 20 where:

the material of the first part comprises a member selected from the group consisting of beryllium-copper and stainless steel.

22. Electrical apparatus comprising:

a first contact element with a flexible whip-like structure including a rod with a conductive path along at least a surface of the rod;

a second contact element that includes a rod portion having an end proximate to which there is joined with the rod portion a first end of a pin on which a roller, with an outer rim, is located and free to rotate, a second end of the pin being joined with a cam bar, and the rod portion, pin, roller, and cam bar all being electrically conductive;

the first and second contact elements being conductively attached respectively to first and second relatively movable electrically conductive parts in a combination in which the first and second electrically conductive parts are relatively moveable from a first position to a second position and from the second position to the

first position during which movements the first and second contact elements make sliding conductive engagement including, in movement from the first position to the second position, sliding conductive engagement of the conductive path of the first contact element with the rim of the roller of the second contact element.

5                   23. The electrical apparatus of claim 22 where:

the rod of the first contact element includes a tip portion of a nonmetallic material having one or more conductors on its surface that is joined with an end of an all-metal base portion with continuous conductivity between the base portion and the conductive path on the tip portion and an opposite end of the base portion is joined with  
10 the first relatively movable electrically conductive part;

the combination being arranged so that, in a movement from the first position to the second position, sliding conductive engagement of the first and second contact elements occurs between the base portion of the first contact element and the rod portion of the second contact element and, subsequently in such movement, between the  
15 conductive path on the tip portion of the first contact element and the rim of the roller of the second contact; and,

in a movement from the second position to the first position, sliding conductive engagement of the first and second contact elements occurs, in sequence, between the base portion of the first contact element and the cam bar of the second  
20 contact element and, subsequently in such movement, between the base portion of the first contact element and the rod portion of the second contact element.

24. The electrical apparatus of claim 23 where:

the nonmetallic material of the tip portion of the first electrical contact principally comprises fiber-reinforced plastic;

25                   the arrangement is such that the conductive path on the nonmetallic material of the first contact element conductively engages the second contact element only at the rim of the roller and only in a movement of the parts from the first position to the second position.

25. The electrical apparatus of claim 23 where:

30                   the first and second relatively movable parts are respective contact arms of an air break switch that each support respective switch contacts; and

the movement from the first to the second position is a movement from a closed position to an open position of the switch contacts and a movement from the second position to the first position is a movement from an open position to a closed position of the switch contacts.

5                   26. The electrical apparatus of claim 23 where:

the sliding engagement, during movement from the closed to the open position, of the base portion of the first contact element with the rod portion of the second contact element initially occurs prior to separation of the switch contacts and that of the conductive path on the tip portion of the first contact element with the rim of the roller of  
10 the second contact element occurs after separation of the switch contacts.

27. An air break switch comprising:

first and second interengaging switch contacts and a switch operating mechanism for opening and closing operations of the switch contacts by relative movement of the contacts;

15                   an arc extinguishing whip and a latch conductively connected with respective ones of the contacts;

the whip having a first all-metal portion conductively connected with one of the contacts and a second portion comprising one or more concentric rods of material of a different composition than the first portion with a continuous conductive path on an  
20 exterior surface of the outermost rod that includes one or more conductors having one or more metal strands bonded to the surface of the rod by an adhesive, and with the conductive path on the outermost rod connected with the first portion at a joint including a metal spine located within the interior of the second portion;

the latch including conductive members comprising a rod portion  
25 connected at one end with the other of the contacts and having a second end proximate to which a pin is attached to the rod portion with a roller free to rotate thereon, the latch further comprising a cam bar attached to the pin on a side of the roller opposite the rod portion;

the whip, the latch and the respective contacts being arranged in a  
30 combination that causes sliding conductive engagement between the whip and the latch during opening and closing operations of the switch contacts by the switch operating

mechanism including, in a switch opening operation, sliding conductive engagement of the conductive path on the whip second portion with the roller of the latch.

28. A switch in accordance with claim 27 where:

5 the one or more rods of the whip second portion comprise fiber-reinforced plastic material;

the one or more metal conductors on the exterior surface of the outermost nonmetallic rod include at least one conductor selected from the group consisting of metal braids and metal wires and the adhesive by which bonding of the conductors to the surface occurs includes a resinous material containing metallic particles;

10 the one or more nonmetallic rods of the whip second portion are tapered, tubular rods with their one or more blunt ends firmly together at a common axial point within a joint with the whip first portion with each other and with the metal spine which is tapered in the same direction as the nonmetallic rod or rods; and

the combination of whip, latch and contacts causes sliding conductive engagement during a switch opening operation between the whip first portion and the latch rod portion prior to engagement of the whip second portion with the roller; and the combination of whip, latch and contacts also have sliding conductive engagement during a switch closing operation between the whip first portion and the latch cam bar prior to engagement between the whip first portion and the latch rod portion.

20 29. A switch in accordance with claim 27 where:

the switch is a center break switch with the switch contacts conductively joined with respective contact arms that both are subject to movement by the switch operating mechanism.

30. A switch in accordance with claim 27 where:

25 the switch is a vertical break switch with the one of the switch contacts to which the whip is conductively connected being joined with a contact arm subject to movement by the switch operating mechanism while the other switch contact is stationary.

31. The structure of claim 13 where:

the first part is a metal spring rod and the second part is a rod of fiber reinforced plastic polymer with a surface conductor comprising a wound wire or wire braid bonded to the polymer rod by a flexible conductive polymer adhesive; and

5 the first part and the second part are such that the first part imparts accelerating force to the second part after release of the second part from conductive engagement with another contact element during which the first part and the second part have been flexed.

32. A switch in accordance with claim 27 where:

10 the whip, the latch, and the respective contacts are further arranged such that during an opening operation, after flexing of the whip against the latch and separation of the whip from the latch occurs, an electric arc is drawn between a tip of the conductive path on the whip second portion and the roller of the latch, and during a closing operation an electric arc is drawn between the whip first portion and the cam bar of the latch.

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